IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Appl. No.	:	09/741,672
Appellant(s)	:	BUIJSSE, Bart
Filed	:	19 December 2000
Title	:	X-RAY MICROSCOPE HAVING AN X-RAY SOURCE FOR SOFT X-RAYS
TC/A.U.	:	2882
Examiner	:	YUN, Jurie
Atty. Docket	:	PHQ 99,015

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APPELLANT'S APPEAL BRIEF

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BRIEF OF APPELLANT

This Brief of Appellant follows a Notice of Appeal, dated 29 March 2005, appealing the decision dated 4 November 2004, of the Examiner finally rejecting claims 1-8 of the application. The fee set forth in 37 CFR 1.17(c) for this Brief is hereby authorized to be charged to Deposit Account No. 501,850.

REAL PARTY IN INTEREST

The real party in interest in this appeal is the assignee of all rights in and to the subject application, Koninklijke Philips Electronics, N.V. of The Netherlands.

RELATED APPEALS AND INTERFERENCES

To the best of the knowledge of the undersigned, no other appeals or interferences are known to Appellants, Appellants' legal representatives, or assignee which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

STATUS OF CLAIMS

Of the original claims 1-8, claims 1-8 have all been amended. Claims 1-8 now stand finally rejected as set forth in the Final Office Action dated 4 November 2004, and are the subject of this appeal.

STATUS OF AMENDMENTS

Claims 1 and 6 were amended subsequent to the Final Office action. This amendment was not entered for purposes of Appeal, per the Advisory Action of the Examiner dated 23 March 2005, and accordingly the amendment is not shown in the CLAIMS ON APPEAL appended hereto.

SUMMARY OF THE CLAIMED SUBJECT MATTER

The invention relates to an X-ray microscope which includes a device for generating X-rays, which device is provided with means for producing a fluid jet, and means for forming a focused radiation beam whose focus is situated on the fluid jet. (Specification, page 1, lines 1-5)

A device for generating soft X-rays is known from the published patent application WO 97/40650 (PCT/SE 97/00697). The means for producing a fluid jet in the known device are formed by a nozzle wherefrom a fluid such as water is ejected under a high pressure. The means for producing a focused radiation beam are formed by a combination of a pulsating laser and a focusing lens which focuses the pulsating radiation beam produced by the laser in such a manner that the focus is situated on the fluid jet. Because of the high power density of the laser pulses, the laser light thus induces a plasma in the fluid jet, thus generating said soft X-rays. The cited patent application describes how these X-rays, notably those of a wavelength of 2.3-4.4 nm, can be used for X-ray microscopy. (Specification, page 1, lines 6-14)

Generating X-rays by way of pulsed laser plasma emission has a number of drawbacks. (Specification, page 1, lines 15-16)

A first drawback in this respect is due to the fact that it is necessary to operate the laser in the pulsating mode in order to achieve an adequate power density of the laser. The cited patent application mentions a power density of from 10^{13}-10^{15} W/cm^2; if this power is to be generated by means of a laser in continuous operation, an extremely large laser would be required. As a result, this known X-ray source produces only X-

rays of a pulsating nature. (Specification, page 1, lines 17-21)

A further drawback of laser-induced plasma emission consists in the phenomenon that many particles (molecules, radicals, atoms (ionized or not), which usually have a high kinetic energy and may be very reactive chemically are present in the vicinity of the location where the X-rays are formed (the X-ray spot). The formation of these particles can be explained as follows: when energy is applied to the target (so the fluid jet) by means of laser light, as the intensity increases first the electrons of the outer shell of the target material will be ionized whereas the electrons of the inner shells, producing the X-rays, are excited only after that. The particles then formed could damage the sample to be examined by means of the X-ray microscope. In order to mitigate or prevent such damage, it is feasible to arrange an optical intermediate element (for example, a condenser lens in the form of a Fresnel zone plate) between the physical X-ray spot and the actually desired location of the X-ray spot, thus creating an adequate distance between the X-ray spot and the sample without seriously affecting the imaging properties of the X-ray microscope. Because condenser lenses are not very effective in the X-ray field, however, a considerable part of the X-ray power generated for the imaging in the X-ray microscope is thus lost. Moreover, some other types of condensers (for example, multilayer mirrors or grazing incidence mirrors) are very susceptible to damage by said high energetic particles. (Specification, page 1, line 22 through page 2, line 9)

It is an object of the invention to avoid the above-described drawbacks by providing an X-ray source for comparatively soft X-rays which can operate continuously while

forming no or hardly any detrimental particles in the X-ray target. (Specification, page 2, lines 10-12)

According to the invention, a fluid jet is irradiated by a focused radiation beam focused on the fluid jet and consisting of a beam of electrically charged particles. (Specification, page 2, lines 12-15) (Claim 1)

Because of the much shorter wavelength of said particles compared to a laser light, the focus of the particle beam can be much smaller than the focus of a laser beam. (Specification, page 2, lines 15-17)

The invention offers an additional advantage in that the energy of the electrically charged particles can be continuously controlled in a wide range by variation of the acceleration voltage of said particles. (Specification, page 2, lines 17-19)

In a preferred embodiment of the invention, the beam of electrically charged particles is formed by an electron beam. This embodiment offers the advantage that use can be made of existing apparatus such as a scanning electron microscope. Such apparatus is arranged notably to obtain a very small electron focus, that is, a focus with a diameter as small as a few nanometers. (Specification, page 2, lines 21-25)(Claim 2)

In a further embodiment of the invention, the cross-section of the fluid jet in the direction of the focused beam is smaller than that in the direction transversely thereof. This embodiment is important in all cases where the particle beam has a width which is larger than approximately the penetration depth into the fluid jet. If a fluid jet having a circular cross-section were used in such circumstances, the x-rays generated in a comparatively thin region at the surface of the jet would be absorbed in the interior of the jet,

preventing a useful yield of the x-rays. This adverse effect is strongly mitigated or even avoided when a "flattened" fluid jet is used. (Specification, page 2, lines 26-33)(Claim 3)

In another embodiment of the invention, the fluid jet consists mainly of liquid oxygen or nitrogen. In addition to the advantage that a fluid jet of a liquefied gas has excellent cooling properties, and hence can be exposed to heavy thermal loading, such a fluid jet also has a high degree of spectral purity, notably in the range of soft x-rays, that is, in the so-called water window (wavelength λ =2.3-4.4 nm). This wavelength range is particularly suitable for the examination of biological samples by means of an x-ray microscope, because the absorption contrast between water and carbon is maximum in this range. (Specification, page 3, lines 1-7)(Claim 4)

In another embodiment of the invention, the means for producing a focused beam of electrically charged particles includes a standard electron gun for a cathode ray tube, the x-ray microscope also being provided with a condenser lens which is arranged between the fluid jet and the object to be imaged by means of the x-ray microscope. The use of such a standard electron gun is advantageous in that such devices are already manufactured in bulk and have already proven their effectiveness for many years. The use of such a standard electron gun is also advantageous in that such electron sources are capable of delivering a comparatively large current (of the order of magnitude of 1 mA). The electron spot, however, has a dimension of the order of magnitude of 50 µm, being of the same order of magnitude as the dimensions of the object to be imaged, so that in this case a condenser lens is required which concentrates the radiation from the x-ray spot onto the sample. Even though some x-ray intensity is lost due to the use of the

condenser, the current in the electron beam is so large that this loss is more than compensated for. (Specification, page 3, lines 8-20)(Claim 5)

In another embodiment of the invention, an electron microscope produces a focused electron beam and is provided with a device for generating x-rays which includes means for producing a fluid jet and means for directing the focus of the electron beam onto the fluid jet. (Specification, page 3, lines 21-25)(Claim 6)

In another embodiment of the invention, an x-ray microscope is incorporated in the electron microscope, the device for generating x-rays then acting as an x-ray source for the x-ray microscope. (Specification, page 3, lines 25-27)(Claim 7)

In another embodiment of the invention, a scanning electron microscope is employed, because such a microscope can readily operate with acceleration voltages of the electron beam which are of the order of magnitude of from 1 to 10 kV; these values correspond to values necessary to generate soft x-rays in the water window. (Specification, page 3, lines 27-31)(Claim 8)

GROUND(S) OF REJECTION TO BE REVIEWED ON APPEAL

The grounds of rejection to be reviewed on appeal are:

1. Are claims 1-3 and 6-8 unpatentable over Wang (U.S. patent 5,044,001) in view of Smither et al. (U.S. patent 4,953,191) (herein 'Smither')?

2. Is claim 4 unpatentable over Wang in view of Smither as applied above, and further in view of Berglund et al. (Rev. Sci. Instrum. 69, 2361, 1998)(herein 'Berglund')?

3. Is claim 5 unpatentable over Wang in view of Smither as applied above, and further in view of Iketaki et al. (U.S. patent 5,835,262)(herein 'Iketaki')?

ARGUMENT

1. Are claims 1-3 and 6-8 unpatentable over Wang (U.S. patent 5,044,001) in view of Smither et al. (U.S. patent 4,953,191) (herein 'Smither')?

Claims 1-3 and 6-8 are rejected under 35 USC 103(a) as being unpatentable over Wang in view of Smither.

Wang shows an x-ray microscope for investigating materials, especially biological specimens, utilizing a focused accelerated beam of electrons within an evacuated chamber, striking a metal foil within the chamber and exposing a specimen outside the evacuated chamber to x-rays generated in the metal foil.

However, Wang does not teach or suggest an x-ray source comprised of a fluid jet or stream in combination with a radiation beam.

Smither shows an x-ray source comprised of a stream of liquid gallium, not a jet, and a stream of electrons.

The Examiner has argued that Smither's stream is a jet because it meets the McGraw Hill Dictionary definition of 'a strong, well-defined stream of liquid, issuing from an orifice or nozzle or moving in a contracted duct', citing col. 4, lines 26-30 of the reference.

It is well settled that to find the meaning of terms used in a patent application, the first source should be Appellant's

own specification. Appellant is entitled to be his own lexicographer.

On page 1, lines 6-9 of Appellant's specification, it is stated:

> A device for generating soft X-rays is known from the published patent application WO 97/40650 (PCT/SE 97/00697). The means for producing a fluid jet in the known device are formed by a nozzle wherefrom a fluid such as water is ejected under a high pressure.

WO 97/40650 further describes the formation of a jet on page 6, lines 24-34, as follows:

> For the forming of microscopic and spatially stable jets of liquid in vacuum, use is here made of a spatially continuous jet 17 of liquid, which forms in a vacuum chamber 8 as is evident from Fig. 2. The liquid 7 is urged under high pressure (usually 5-100 atmospheres) from a pump or pressure vessel 14 through a small nozzle 10, the **diameter** of which usually is smaller than about 100Hm and typically one or two up to a few tens of micrometers. This results in a stable microscopic jet 17 of liquid of essentially the same **diameter** as the nozzle 10 and a speed of about 10-100 m/s. (emphasis added)

Since the jet is formed by a nozzle having a diameter, and the jet itself has the same diameter as the nozzle, it is clear that the jet has a circular or nearly circular cross-section.

Appellant's specification provides three examples of jets. These are illustrated in cross-section in Figs. 1a, 1b and 1c. In Figs. 1a, 1c, the cross-sections of the jets are circular. In Fig. 1c, the cross-section of the jet is elliptical. Thus, Appellant's jet is characterized by having a curvilinear cross-section.

In contrast, Smither's stream is described as being flat. See, e.g., col. 3, line 2. In order to attain this configuration, Smither employs a distribution head (22), not a

nozzle, and a stainless steel plate (14) across which the stream (16) flows. See col. 4, lines 8-10.

As can be seen from Fig. 1 of Smither, the distribution head has a rectilinear cross-section, not a curvilinear cross-section, and directs the stream onto the plate. Consequently the stream is flat, not curvilinear.

Moreover, Smither does not teach or suggest to focus a radiation beam on the stream. As shown in Fig. 1, and described at col. 4, lines 5 and 6, Smither's beam emanates from a slit in the form of a flat stream of parallel beams (18), oriented transversely to the stream, so as to irradiate a substantial portion of the width of the stream. The parallel beams do not meet or even converge. Thus, the beam is not focused.

Accordingly, Smither fails to teach or suggest an x-ray source comprised of a radiation beam focused on a fluid jet, and thus the combination of Smither and Wang fails to teach or suggest an x-ray microscope incorporating such a source.

The rejection is therefore in error and should be reversed.

<u>Argument with respect to claim 2</u>

Claim 2 calls for the beam of electrically charged particles to comprise an electron beam.

Wang shows an x-ray microscope employing an electron beam. Smither shows an x-ray source employing an electron beam. However, as stated above, neither Wang nor Smither teach or suggest an x-ray source comprised of a fluid jet and a charged particle beam focused on the jet.

<u>Argument with respect to claim 3</u>

Claim 3 calls for the cross-section of the fluid jet in the direction of the focused beam to be smaller than that in the transverse direction.

Neither Wang nor Smither show a fluid jet. Smither shows a flat stream, which of course has a greater dimension in one direction than in the transverse direction. However, as already stated, this flat stream is not a jet.

Argument with respect to claim 6

Claim 6 is similar to claim 2 except that it calls for an electron microscope to produce the focused electron beam.

Wang describes prior attempts to utilize an electron microscope to produce an x-ray microscope, but rejects these attempts as 'complex and difficult'. Col. 1, lines 50-65.

Smither does not mention an electron microscope.

Argument with respect to claim 7

Claim 7 calls for the electron microscope of Claim 6 to include an x-ray microscope, the device for generating x-rays acting as the x-ray source for the x-ray microscope.

As already stated, neither Wang nor Smither teach or suggest a device for generating x-rays comprised of a fluid jet and an electron beam focused on the jet. Nor do they teach or suggest the use of an electron microscope to produce an x-ray microscope.

Argument with respect to claim 8

Claim 8 calls for the electron microscope of Claim 6 to be a scanning electron microscope.

As already stated, neither Wang nor Smither teach or suggest the use of an electron microscope of any type to produce an x-ray microscope. In fact, Wang actually teaches away from such use since such use has been shown to be 'complex and difficult'.

In summary, claims 1-3 and 6-8 are not obvious over the teachings of Wang and Smither, whether taken alone or in

combination, and the rejection is therefore in error and should be reversed.

2. Is claim 4 unpatentable over Wang in view of Smither as applied above, and further in view of Berglund et al. (Rev. Sci. Instrum. 69, 2361, 1998)(herein 'Berglund')?

Claim 4 is rejected under 35 USC 103(a) as being unpatentable over Wang in view of Smither as applied above, and further in view of Berglund.

Berglund discloses a liquid jet target for an x-ray source. The possible liquids disclosed include nitrogen, oxygen, neon, argon or xenon.

Berglund does not provide any guidance regarding a choice of one or more of these liquids over the others. Thus, it would not be obvious to choose oxygen and nitrogen over neon, argon or xenon.

Moreover, x-rays are formed by focusing a laser beam on the liquid jet. Thus, Berglund fails to teach or suggest the use of a focused radiation beam of charged particles, as required by claim 1, upon which claim 4 is dependent.

Accordingly, claim 4 is patentable over the combination of Wang, Smither and Berglund, and the rejection is in error and should be reversed.

3. Is claim 5 unpatentable over Wang in view of Smither as applied above, and further in view of Iketaki et al. (U.S. patent 5,835,262)(herein 'Iketaki')?

Claim 5 is rejected under 35 USC 103(a) as being unpatentable over Wang in view of Smither as applied above, and further in view of Iketaki.

Iketaki discloses an x-ray microscope (Fig. 7) including a source (21-23), a sample (27) and a condenser lens (24) between the source and the sample.

However, claim 5 calls for the source of charged particles to comprise an electron gun for a cathode ray tube, as well as calling for a condenser lens disposed between the source and the sample.

Iketaki does not disclose a source of charged particles of any kind, but rather discloses a source of laser radiation (21).

Accordingly, claim 5 is patentable over the combination of Wang, Smither and Iketaki, and the rejection is in error and should be reversed.

CONCLUSION

In conclusion, the applied references, whether taken alone or in combination, fail to teach or suggest Appellant's invention as presented in the claims on appeal.

In view of the foregoing, Appellant respectfully requests that the Board reverse the rejections of record.

Respectfully submitted,

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APPENDIX

CLAIMS ON APPEAL

1. An X-ray microscope which includes a device for generating X-rays, which device is provided with:

- means for producing a fluid jet,
- means for forming a focused radiation beam whose focus is situated on the fluid jet,

said focused radiation beam comprising a beam of electrically charged particles.

2. An X-ray microscope as claimed in Claim 1, wherein the beam of electrically charged particles comprises an electron beam.

3. An X-ray microscope as claimed in Claim 1, wherein the cross-section of the fluid jet in the direction of the focused beam is smaller than that in the direction transversely thereof.

4. An X-ray microscope as claimed in Claim 1, wherein the fluid jet consists essentially of liquid oxygen or nitrogen.

5. An X-ray microscope as claimed in Claim 1, wherein the means for producing a focused beam of electrically charged particles comprises an electron gun for a cathode ray tube, the X-ray microscope including a condenser lens disposed between the fluid jet and an object to be imaged by means of the X-ray microscope.

6. An electron microscope for producing a focused electron beam and including a device for generating X-rays,

said device including:

- means for producing a fluid jet,
- means for directing the focus of the electron beam onto the fluid jet.

7. An electron microscope as claimed in Claim 6 and including an X-ray microscope, said device for generating X-rays acting as the X-ray source for the X-ray microscope.

8. An electron microscope as claimed in Claim 6, the electron microscope being a scanning electron microscope.